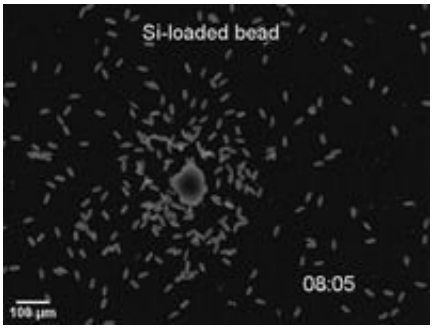
Sex or food? Decision-making in single-cell organisms

October 17 2018



Diatom cells aggregate around a silicate-loaded bead. Credit: Karen Grace Bondoc, FSU Jena

Unicellular diatoms are able to adapt their behavior to different external stimuli based on an evaluation of their own needs. This was discovered by scientists of the Friedrich Schiller University and the Max Planck Institute for Chemical Ecology in Jena, Germany, together with partners from Belgium. The algae depend on nutrients in order to reproduce. However, they also need reproductive partners, which they find by following pheromone traces. In experiments, Seminavis robusta diatoms directed their orientation either toward nutrient sources or reproductive partners, depending on the degree of starvation and the need to mate. This represents a primitive form of behavioral biology. The study is published in *The ISME Journal*.

Diatoms dominate marine phytoplankton, which is ubiquitous in the

oceans. On shores and beaches, these algae can be observed as biofilms on rocks and other surfaces. Diatoms are the food source for many marine animals, and are also responsible for an extremely important ecosystem service: They contribute significantly to global photosynthesis and thus to the production of atmospheric oxygen on Earth. Moreover, they are discussed as possible producers of biofuels.

The diatom Seminavis robusta is an ideal model organism for behavioral studies in the lab. The cells respond to environmental conditions, and their sexuality can be controlled. The research group of Georg Pohnert, professor of Instrumental Analytics/Bioorganic Analytics at Friedrich Schiller University and head of the Max Planck Fellow Group at the Max Planck Institute for Chemical Ecology, wanted to know whether the tiny organisms are able to make decisions about what they needed more urgently: food or sexual mates.

In order to find out, the scientists cultivated cells under different conditions. In particular, the cells were confronted with different amounts of nutrients and sex pheromones. Since diatoms primarily reproduce asexually by cell division, sexual reproduction may become necessary for their survival if the cells become smaller and smaller after continuous division. After all, the cells die if they become too small and fall below a minimum size. Diatoms also search actively for nutrients they need for the formation of their cell walls. They can trace silicate minerals in their environment and move actively toward this food source . A recent study showed that they are attracted by the odor of the minerals (see press release The odor of stones, February 4, 2016).

"It is striking that even unicellular organisms that obviously lack a nervous system can process different stimuli and even evaluate their individual needs. Our study showed that diatoms can adapt their behavior flexibly to environmental changes. They also responded differently depending on their need to mate. We observed that the

diatoms moved toward pheromones or food sources depending on how hungry they were for sex or nutrients. Until now, this kind of decision-making has only been attributed to higher organisms," says Pohnert.

The decision of one diatom does not only determine the fate of a single cell. Moreover, it is crucial for the dynamics of biofilms, which are composed of communities of countless diatoms. Using mathematical models, the researchers calculated interactions between cell density and the availability of nutrients (silicate minerals) and mating partners (pheromones). Based on these results, the scientists are able to explain how biofilms are organized and why they are often patchy and distributed in certain patterns.

The scientist would now like to find how the single-cell organisms perceive, process and evaluate chemical signals. "Our goal is to identify the corresponding receptors and signal processing pathways, but this will be a very complex endeavor given the fact that we know so little about these important micoralagae," says Georg Pohnert.

More information: Karen Grace V. Bondoc et al, Decision-making of the benthic diatom Seminavis robusta searching for inorganic nutrients and pheromones, *The ISME Journal* (2018). DOI: 10.1038/s41396-018-0299-2

Provided by Max Planck Society